Subnatural Linewidths in Core Level Excitation Spectra	X1B

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While the width of an electronic resonance in the absorption spectrum of a gaseous atom or molecule is always determined by the core hole lifetime, in electron spectra a line narrowing below the natural linewidth has been found at the energy of the resonance, when it is excited by a very narrow photon bandpass. This aspect of the so-called 'resonant Auger Raman effect' can be explained most easily by energy conservation.

An analogous effect in an *absorption* spectrum has recently been observed at X1B [1]. We have measured a core excitation spectrum on the N_2 $1s \rightarrow \pi^*$ transition, in one case recording the low kinetic energy electron yield (Fig. 1) and in the other case recording only a narrow band of electron kinetic energies only (Fig. 2). The latter spectra are often termed constant final state (CFS) scans. In particular, we have set the electron analyser to the kinetic energy of the participator transitions $1\sigma_u^{-1}1\pi_g \rightarrow 1\pi_u^{-1}, \Delta v' = 0$. As is obvious from the figures, the latter spectrum shows an apparently better resolution. This is caused by the analyser bandpass filtering out electrons that do not fall inside a certain kinetic energy window. The resolution enhancement obtained can be compared to the use of narrow-band fluorescence detection for resolution enhancement, a technique invented earlier at the NSLS [2].

Since the potential curves of excited and final state are parallel here, decay events contributing to the curve in Fig. 2 always derive from different *vibrational* components of the same *electronic* states. This need not be the case in general, and care must be taken in the interpretation of such CFS scans.

[1] A. Kivimäki, K. Maier, U. Hergenhahn, M.N. Piancastelli, B. Kempgens, A. Rüdel, and A.M. Bradshaw, Phys. Rev. Lett. **81**, 301 (1998).

[2] K. Hämäläinen, D.P. Siddons, J.B. Hastings, and L.E. Berman, Phys. Rev. Lett. **67**, 2850 (1991).

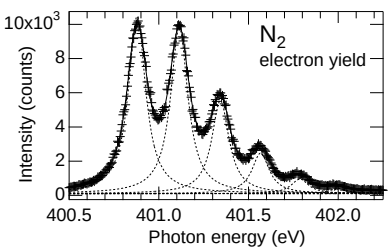

Figure 1. Wide-band electron yield spectrum at the N_2 $1s \rightarrow \pi^*$ excitation. The monochromator resolution was about 54 meV (slits 5/5 μm). This curve has the form of the normal photoabsorption spectrum.

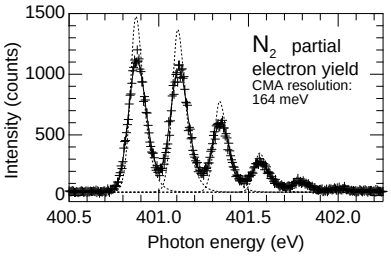

Figure 2. Narrow-band electron yield spectrum recorded at identical monochromator settings by detecting only 384.2 eV electrons with 7.5 eV analyser pass energy. Note the apparently higher resolution compared to Fig. 1.